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THESIS

A METHODOLOGY FOR EVALUATING THE PERFORMANCE OF OPERATIONAL FIREPOWER DURING A COMPUTER AIDED EXERCISE

by

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September 1996

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Thesis
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One of the primary tools available to a Joint Commander-in-Chief (CINC) for training his staff on their joint mission essential tasks is a command post exercise (CPX) supported by a computer simulation model. This is commonly referred to as a Computer Aided Exercise (CAX). Computer Aided Exercises are an essential part of training a component staff; however, one weakness with these valuable tools lies in the measurement of the level of training received by the players. In most CPXs the players rapidly disperse after the exercise and little quantitative data are captured during the running of the CAX that allows for a quick post exercise analysis. This research presents a methodology for evaluating the performance of joint operational firepower tasks as set forth in the Universal Joint Task List. While demonstrating this methodology for developing quantifiable measures of effectiveness in operational firepower, this thesis also shows how the relationship of operational firepower and operational intelligence can be refined for enhanced firepower effectiveness.

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A METHODOLOGY FOR EVALUATING THE PERFORMANCE OF OPERATIONAL FIREPOWER DURING A COMPUTER AIDED EXERCISE

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ABSTRACT

One of the primary tools available to a Joint Commander-in-Chief (CINC) for training his staff on their joint mission essential tasks is a command post exercise (CPX) supported by a computer simulation model. This is commonly referred to as a Computer Aided Exercise (CAX). Computer Aided Exercises are an essential part of training a component staff; however, one weakness with these valuable tools lies in the measurement of the level of training received by the players. In most CPXs the players rapidly disperse after the exercise and little quantitative data are captured during the running of the CAX that allows for a quick post exercise analysis. This research presents a methodology for evaluating the performance of joint operational firepower tasks as set forth in the Universal Joint Task List. While demonstrating this methodology for developing quantifiable measures of effectiveness in operational firepower, this thesis also shows how the relationship of operational firepower and operational intelligence can be refined for enhanced firepower effectiveness.

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To my wife Vicky, without her support this could not have been possible.

EXECUTIVE SUMMARY

One of the primary tools available to a Joint Commander-in-Chief (CINC) for training his staff on their joint mission essential tasks is a command post exercise (CPX) supported by a computer simulation model. Computer Aided Exercises (CAXs) are an essential part of training a component staff; however, one weakness with these valuable tools lies in the measurement of the level of training received by the players. In most CPXs the players rapidly disperse after the exercise and little quantitative data are captured during the running of the CAX that allows for a quick post exercise analysis. Assessment of process performance in relationship to ability to perform mission essential tasks is important for two reasons. First, it helps to determine whether training resources are being used wisely and if the training program is achieving desired results. Second, it helps to determine which mission essential tasks are in need of additional training.

The objective of this thesis is to develop an exercise analysis methodology for evaluating the execution of joint tasks during a CAX. Specific objectives are: 1) Demonstrate a methodology for developing quantifiable measures of effectiveness (MOEs) designed to work in conjunction with the data retrieved from a computer simulation. These measures must reflect the hierarchical structure of tasks as applied to the three levels of war (vertical linkage), and functionality considerations between related enabling tasks (horizontal linkage). 2) Determine methods for implementing staff plans and capturing task performance data within the design of the simulation. This is intended to support the exercise analysis by capturing critical decisions, assumptions and causal

factors inherent within staff actions as they relate to plan execution and provides a framework within which conclusions about observed outcomes can be based. This objective involves demonstrating the methodology in an exercise conducted utilizing the Joint Theater Level Simulation (JTLS). Implicit tasks include aligning plan requirements with the model's database, developing algorithms required in post processing, and specifying output file format.

The Universal Joint Task List (UJTL) is a comprehensive listing of all joint tasks pertaining to the Armed Forces of the United States of America. It provides a common language for describing joint warfare capabilities throughout the entire range of military operations to include military operations other than war (MOOTW). Specifically, tasks are defined as they relate to the strategic (national and theater), operational, and tactical levels of war. Each joint task is broken down into *supporting* tasks which may further be broken down into *enabling* tasks.

Essential to this methodology is the understanding that a common *functionality* exists at the different levels of war. For example, at the strategic theater level, the UJTL task "Employ Theater Strategic Firepower" (ST 3) is related to "Employ Operational Firepower" (OP 3) at the operational level. Furthermore, employ operational firepower is related to the tactical level task "Employ Firepower" (TA 3). A horizontal link also exists within the UJTL. This link pertains to the dependence of one task on another at the same level of war. For instance, operational firepower cannot be effectively employed if operational intelligence (OP 2) is ignored. Additionally, operational maneuver (OP 1) is seldom successful without effective operational firepower. Hence, to provide operational

firepower successfully, joint staffs must be proficient in their ability to work both vertically and horizontally throughout the UJTL. In analysis, it is necessary to reflect the dynamics of vertical and horizontal linkages as a matter of aggregation and in the interest of maintaining the appropriate level of abstraction.

This research presents a methodology for evaluating the performance of joint operational firepower tasks as set forth in the Universal Joint Task List. While demonstrating this methodology for developing quantifiable measures of effectiveness in operational firepower, this thesis also shows how the relationship of operational firepower and operational intelligence can be refined for enhanced firepower effectiveness. Implementation of the methodology places no burden on the staff during the course of the exercise. Additionally, it is relatively uncomplicated and conducive to quick and insightful analysis.

I. INTRODUCTION

A. BACKGROUND

The Chairman Joint Chiefs of Staff (CJCS) Memorandum of Policy 26 (MOP 26) establishes a program for carrying out the joint training responsibilities for the CJCS, the Unified Commanders in Chief (CINCs), and the CINCs' component staffs. MOP 26 institutes a method for identifying training requirements through the review of the CINC's mission and the compilation of Joint Mission Essential Task List (JMETL). A CINC's JMETL is intended to provide the basis for all joint training.

The Universal Joint Task List (UJTL) [Ref. 1], a supplement to the Joint Training Manual (MCM-71-92), is a comprehensive listing of all joint tasks pertaining to the Armed Forces of the United States of America. It provides a common language for describing joint warfare capabilities throughout the entire range of military operations to include military operations other than war (MOOTW). Specifically, tasks are defined as they relate to the strategic (national and theater), operational, and tactical levels of war. Each joint task is broken down into *supporting* tasks which may further be broken down into *enabling* tasks.

One primary training tool available to a CINC for training his staff on their joint mission essential tasks is a command post exercise (CPX) supported by some type of computer simulation model. This is commonly referred to as a Computer Aided Exercise (CAX). The primary role of the computer simulation is to present a decision environment within which the staff can be presented with realistic, stochastic results.

Based on this simulated environment, a staff can implement plans, monitor the current situations, and further develop or alter its plan as dictated by the changing requirements.

B. PROBLEM STATEMENT

The objective of this thesis is to develop an exercise analysis methodology for evaluating the execution of joint tasks during a CAX. Specific objectives are: 1) Demonstrate a methodology for developing quantifiable measures of effectiveness (MOEs) designed to work in conjunction with the data retrieved from a computer simulation. These measures must reflect the hierarchical structure of tasks as applied to the three levels of war (vertical linkage), and functionality considerations between related enabling tasks (horizontal linkage). 2) Determine methods for implementing staff plans and capturing task performance data within the design of the simulation. This is intended to support the exercise analysis by capturing critical decisions, assumptions and causal factors inherent within staff actions as they relate to plan execution; and will provide a framework within which conclusions about observed outcomes can be based. This objective involves demonstrating the methodology in an exercise conducted utilizing the Joint Theater Level Simulation (JTLS). Implicit tasks include aligning plan requirements with the model's database, developing algorithms required in post processing and specifying output file format.

The area that this report will address is the processing of High Payoff Targets (HPTs). HPTs are those targets that must be acquired and attacked to ensure the success of friendly operations [Ref. 2].

It is important to emphasize that this research is part of a larger ongoing research project which provides an overall analysis methodology for many of the joint tasks specified in the UJTL within the context of a CAX. Concurrent with the development of the methodology presented in this paper are related efforts by MAJ Mark Cwick (USMC) [Ref. 3], CPT Kevin Brown (USA) [Ref. 4], CPT John Thurman (USA) [Ref. 5], LT John Mustin (USN) [Ref. 6], and LT Mark Sullivan (USN) [Ref. 7]; all of which involve the UJTL and JTLS. This research also parallels previous research by LT Chris Towery (USN) on intelligence tasks [Ref. 8]; and CPT Ray Combs (USA) on logistics tasks [Ref. 9]. Since the performance of one joint task during a CAX often impacts the performance of another joint task, it is strongly recommended that the reader consider all papers in order to gain insight into the overall analysis methodology which attempts to identify common causal factors that influence significant events that occur during a CAX.

C. THESIS STRUCTURE

Chapter II provides a brief overview of the UJTL and Operational Firepower definitions. Chapter III describes the proposed analysis methodology used to assess staff performance. The methodology focuses on the analysis of significant events. Chapter

IV applies the methodology to a typical exercise scenario using the Joint Theater Level Simulation. Additionally, Chapter IV discusses the data manipulation that is necessary for the post exercise analysis using an existing computer simulation. Chapter V summarizes the methodology and provides recommendations for further refinements and study.

II. JOINT TRAINING PROCESS

> *Military victories are not gained by a single arm, though failure of any arm or service might well be disastrous, but are achieved through the effort of all arms and Services welded into ...a team.* General of the Army George C. Marshall

As the world leader, the United States of America requires the strongest and most capable military. In today's economy, the United States military has no other choice but to learn how to train and fight in the joint arena. With only limited assets, leaders at all levels must learn to train with sister services in order to gain trust, learn limitations and capabilities, maintain proficiency, and, most important, ensure success in the next battle.

A. THE UNIVERSAL JOINT TASK LIST (UJTL)

The Universal Joint Task List (UJTL) [Ref. 1] was developed by the Dynamics Research Corporation (DRC) under the guidance of the Joint Exercise and Training Division (JETD) of the J-7 Directorate, Joint Staff. Over 120 organizations have provided input, all of which have been coordinated through the Joint Staff, CINCs, Services, and other concerned governmental agencies. The UJTL provides a standardized tool for describing requirements in the planning, conducting, assessing and evaluating joint and multinational training. Capabilities described within the UJTL cover the entire range of military operations, to include military operations other than war.

The UJTL is broken down into three levels: Strategic (National Military Strategy and Strategic Theater), Operational, and Tactical (Figure 1). The UJTL involves the joint task list, joint conditions list, and associated task measures. The joint task list

consists of all joint, supporting and enabling tasks at each of the three levels of war. These levels formally specify the required capabilities of the nation's armed forces. The joint conditions list contains various physical, political, social, and military states that describe operational environments. Task measure of effectiveness are parameters describing task performance that, when specified in terms of conditions and a minimum acceptable level of performance, are a statement of task standards. The joint measures list provides performance criteria at the task level to assist commanders in assessing their staff performance and determining those tasks that may require further training. Figure 1 shows the organization and large scale breakdown of the UJTL.

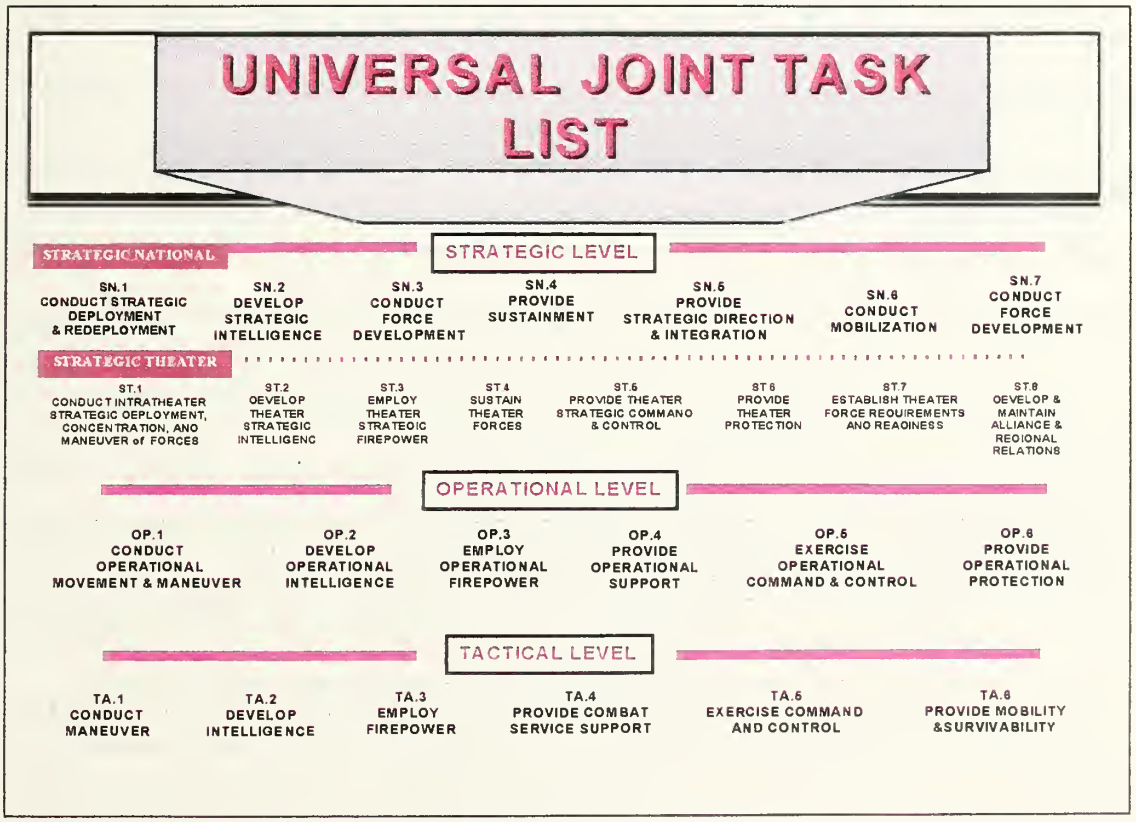
UNIVERSAL JOINT TASK LIST
STRATEGIC NATIONAL
STRATEGIC LEVEL
SN.1 CONDUCT STRATEGIC DEPLOYMENT & REDEPLOYMENT
SN.2 DEVELOP STRATEGIC INTELLIGENCE
SN.3 CONDUCT FORCE DEVELOPMENT
SN.4 PROVIDE SUSTAINMENT
SN.5 PROVIDE STRATEGIC DIRECTION & INTEGRATION
SN.6 CONDUCT MOBILIZATION
SN.7 CONDUCT FORCE DEVELOPMENT
STRATEGIC THEATER
ST.1 CONDUCT INTRATHEATER STRATEGIC OEPLOYMENT, CONCENTRATION, ANO MANEUVER of FORCES
ST.2 OEVELOP THEATER STRATEGIC INTELLIGENC
ST.3 EMPLOY THEATER STRATEOIC FIREPOWER
ST.4 SUSTAIN THEATER FORCES
ST.5 PROVIDE THEATER STRATEGIC COMMANO & CONTROL
ST.6 PROVIDE THEATER PROTECTION
ST.7 ESTABLISH THEATER FORCE REQUIREMENTS ANO REAOINESS
ST.8 OEVELOP & MAINTAIN ALLIANCE & REOIONAL RELATIONS
OPERATIONAL LEVEL
OP.1 CONDUCT OPERATIONAL MOVEMENT & MANEUVER
OP.2 DEVELOP OPERATIONAL INTELLIGENCE
OP.3 EMPLOY OPERATIONAL FIREPOWER
OP.4 PROVIDE OPERATIONAL SUPPORT
OP.5 EXERCISE OPERATIONAL COMMAND & CONTROL
OP.6 PROVIDE OPERATIONAL PROTECTION
TACTICAL LEVEL
TA.1 CONDUCT MANEUVER
TA.2 DEVELOP INTELLIGENCE
TA.3 EMPLOY FIREPOWER
TA.4 PROVIDE COMBAT SERVICE SUPPORT
TA.5 EXERCISE COMMAND AND CONTROL
TA.6 PROVIDE MOBILITY &SURVIVABILITY

Figure 1. Universal Joint Task List (UJTL) depicting the organization broken down into three levels.

B. JOINT MISSION ESSENTIAL TASK LIST (JMETL)

A Joint Mission Essential Task List (JMETL) includes those *tasks* that a regional CINC deems necessary to focus his training efforts in order to accomplish a specific mission. All Joint Mission Essential Tasks must be referenced to the UJTL. A CINC's JMETL is intended to provide the basis for all joint training.

C. JOINT TRAINING PROGRAM

The joint training program encompasses all aspects of the joint training process within the Department of Defense. Its purpose is to better link the joint *training* system and the joint *doctrine* system to provide an improved fighting force for the CINCs. Training must be based on mission requirements, with the highest priority being warfighting; and *joint* training must be guided by joint doctrine. Missions that support national military strategy are assigned to the CINCs. Upon receipt, an analysis is conducted to determine what capabilities are required for the successful completion of the mission. Essential capabilities and requirements for training are reflected in the CINC's JMETL along with joint doctrine and joint tactics, techniques and procedures (JTTP). They are then analyzed in term of appropriate mission conditions, necessary standards, command level responsibility and training resources available in order to generate the CINC's Joint Training Plan and subsequent training schedules. The focus is clearly on defining joint training requirements in order to use scarce resources as efficiently as possible. The Universal Joint Task List plays an essential role in the

overall process of *evaluating* the joint training and readiness process. The focus and product of this thesis will assist in providing direct integration of the CINC's JMETL into the training exercise, allowing for a rapid and accurate analysis of operational firepower.

D. OPERATIONAL FIREPOWER

> *You should not have a favorite weapon. To become overly familiar with one weapon is as much a fault as not knowing it sufficiently well....It is bad for commanders...to have likes and dislikes.* (Miyamoto Musashi, 17th century Japanese warrior, *The Book of Five Rings)*

Joint firepower can be classified as tactical, operational or strategic, based on its intended effect. Operational firepower refers to the application of non-lethal and lethal firepower to achieve a decisive impact on a the conduct of a campaign or major operation. Operational firepower can be joint and multinational. All services contribute capabilities that can be used for operational firepower. To synchronize operations, one component may provide fires to support another component's operation. [Ref. 10] Operational firepower must also be closely integrated and synchronized with the concept of operations for maneuver. In that regard, operational firepower is integrated normally with operational land maneuver for synergistic effects, staying power and more rapid achievement of strategic aims.

Operational firepower includes targeting and attacking land and sea targets whose destruction or neutralization will have a major impact on a subordinate campaign or

major operation. It must be noted that intelligence, at all levels, plays an important role in targeting and the targeting process. In that regard, one cannot look at the definition of operational firepower without considering how it relates to operational intelligence. Operational firepower includes the allocation of joint and multinational air, land, and sea (surface and subsurface) and space means. It can be designed to achieve a single, operationally significant objective that could have a major impact on the campaign and major operation. With accurate intelligence, operational firepower focuses largely on one or more of the following:

* Destruction of critical functions, facilities and forces having operational significance.
* Isolation of a specific battle within the battle space.
* Facilitation of maneuver to operational depths.

Systems capable of providing operational firepower generally include (but are not limited to) land and sea based airpower assets and surface-to-surface firepower. [Ref. 10]

E. TARGETS, TARGET ANALYSIS AND TARGETING

A target is an enemy function, formation, equipment, facility or terrain planned for capture, destruction, neutralization or degradation in order to disrupt, delay or limit the enemy.

Target analysis is the examination of potential targets to determine military importance, priority of attack and weapons required to obtain a desired level of damage. [Ref. 11] Target analysis is done at all levels by the intelligence staffs and sections.

During target analysis High Value Targets (HVTs) and High Payoff Targets (HPTs) are determined. A High Value Target (HVT) is an asset that the enemy commander requires for the successful completion of his mission. [Ref. 2] A High Payoff Target (HPT) is one that must be acquired and attacked to ensure the success of friendly operations. [Ref. 2] In a many cases an enemy element that has been designated as a *critical node* will be targeted and designated as a HPT. A critical node is an element, position, or communication entity whose disruption or distruction immediately degrades the ability of a force to command, control, or effectively conduct combat operations. [Ref. 11]

Targeting is the process of identifying enemy targets and matching them with the appropriate weapon system, taking into account operational requirements and capability. [Ref. 12] Again, intelligence staffs and sections play a key role in targeting. The emphasis of targeting is on *identifying resources* that the enemy can least afford to lose. Denying these resources to the enemy strips him of the initiative; it forces him to conform to friendly battle plans. [Ref. 2]

The targeting methodology is often characterized as *decide-detect-deliver*. The *decide* function results in the approval of the HPT list. It also gives a clear picture of the priorities that apply to tasking of target acquisition (TA) assets, information processing and selection of attack means. The *detect* function is where the TA assets gather information and report their findings to their controlling headquarters, which in turn passes this information to the tasking agency. With regards to the UJTL, the *decide* and *detect* phases fall under the intelligence arenas. The relationship between those tasks in OP 2 (Develop Operational Intelligence) and TA 2 (Develop Intelligence) and OP 3

(Employ Operational Firepower) is critical to this thesis. The main objective of the *deliver* function is the attacking of targets. The delivery of munitions can be from indirect fire assets, airpower, naval gun fire and long range missiles. The *deliver* phase is operational in nature and falls under Employ Operational Firepower (OP 3) in the UJTL.

Conducting *post-attack* battle damage assessment is a task that also falls under TA 2. [Ref 1] This assessment is the yard stick used to determine if previous engagements of a target were sufficient to obtain the desired results. If the desired results are not obtained, the target is re-engaged. This real time or actual intelligence information is critical for effective fires. Without this information, only an assumption can be made about the battle damage and re-engagement. This assumption is referred to as *perceived* battle damage assessment.

While demonstrating a methodology for developing quantifiable measures of effectiveness (MOEs) in operational firepower, this thesis also shows how operational firepower and operational intelligence are linked together. Specific focus is on the time delay between target detection and munitions delivery and the data collection regarding *perceived* battle damage assessment, as well as how these data can be used to determine if previous engagements of a target were sufficient to obtain the desired results.

III. MOE DEVELOPMENT

This chapter introduces a methodology for developing quantifiable measures of effectiveness for evaluating a CINC staff performance in the execution of joint operational firepower and related fire support functions during the conduct of a Computer Aided Exercise (CAX). These performance functions are described in terms of the appropriate Universal Joint Tasks. The answer to the following question is the goal of this methodology: *Was accurate firepower provided in a timely manner so it created the desired outcome for the operational forces?*

This methodology includes structuring related joint tasks and developing issues to performance data requirements (dendritic). Specific steps of this methodology include developing the means to ascertain the effects of firepower during the conduct of a CAX.

Essential to this methodology is the understanding that a common *functionality* exists at the different levels of war (Figure 2). For example, at the strategic theater

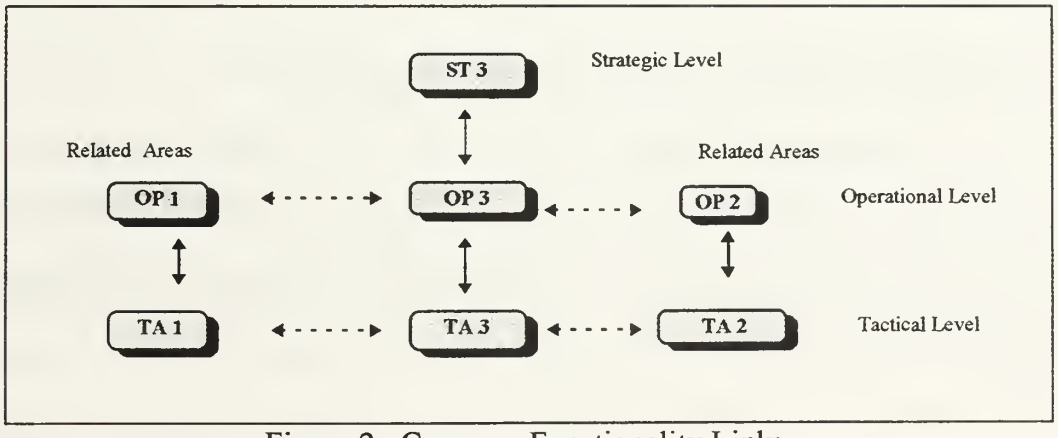

Figure 2. Common Functionality Links.

level, the task "Employ Theater Strategic Firepower" (ST 3) is related to "Employ Operational Firepower" (OP 3) at the operational level. Furthermore, "Employ Operational Firepower" is related to the tactical level task "Employ Firepower" (TA 3). The next section will discuss how these vertical links also show the relationship between the joint, supporting and enabling tasks within the different levels of war. A horizontal link also exists within the UJTL. This link pertains to the dependence of one task on another at the same level of war. For instance, operational firepower cannot be effectively employed if Operational Intelligence (OP 2) is ignored. Additionally, Operational Maneuver (OP 1) is seldom successful without effective operational firepower. Hence, to provide operational firepower successfully, joint staffs must be proficient in their ability to work both vertically and horizontally throughout the UJTL. In analysis, once the vertical and horizontal links are established, then a causal audit trail can be established leading to reasons for success or failure in the staff's approach to operational firepower.

A. TASK DESCRIPTION AND JOINT SCHEMATIC

As previously discussed, the UJTL is broken down into tasks at the three levels of war: strategic, operational, and tactical. It is essential to show the *vertical* and *horizontal* links between these levels and tasks as they apply to operational firepower. However, it is first necessary to describe how *tasks* at each level are broken down into joint, supporting and enabling. Each joint task has a corresponding one digit number, while its

associated supporting and enabling tasks have the same leading number with additional two and three numbers, respectively. Also, some enabling tasks have associated refined enabling task which adds a fourth digit to the task number. Figure 3 shows an example of a task nomenclature breakdown.

Task	*Description*	*Task Number*
Joint	*Employ Operational Firepower*	*OP 3*
Supporting	*Conduct Joint Force Targeting*	*OP 3.1*
Enabling	*Establish Joint Force Targeting Strategy*	*OP 3.1.1*
	Select Operational Targets for Attack	*OP 3.1.3*
	Prioritize High Payoff Targets	*OP 3.1.4*
Joint	*Develop Operational Intelligence*	*OP 2*
Supporting	*Process Operational Information*	*OP 2.3*
Enabling	*Integrate Operational Intelligence*	*OP 2.3.3*
Refined Enabling	*Develop Operational Target Information*	*OP 2.3.3.2*
	Identify Enemy Vulnerabilities	*OP 2.3.3.4*

Figure 3. Example of a UJTL task nomenclature breakdown.

The joint schematic, shown in Figure 4, depicts the relationship among tasks at the three levels of war as they apply to Operational Firepower. Hierarchical relationships regarding respective levels of war are illustrated by the relative vertical positions at each task level. Relationships between joint, supporting, enabling and refined enabling tasks and their vertical relationships are further distinguished by their task number as described above.

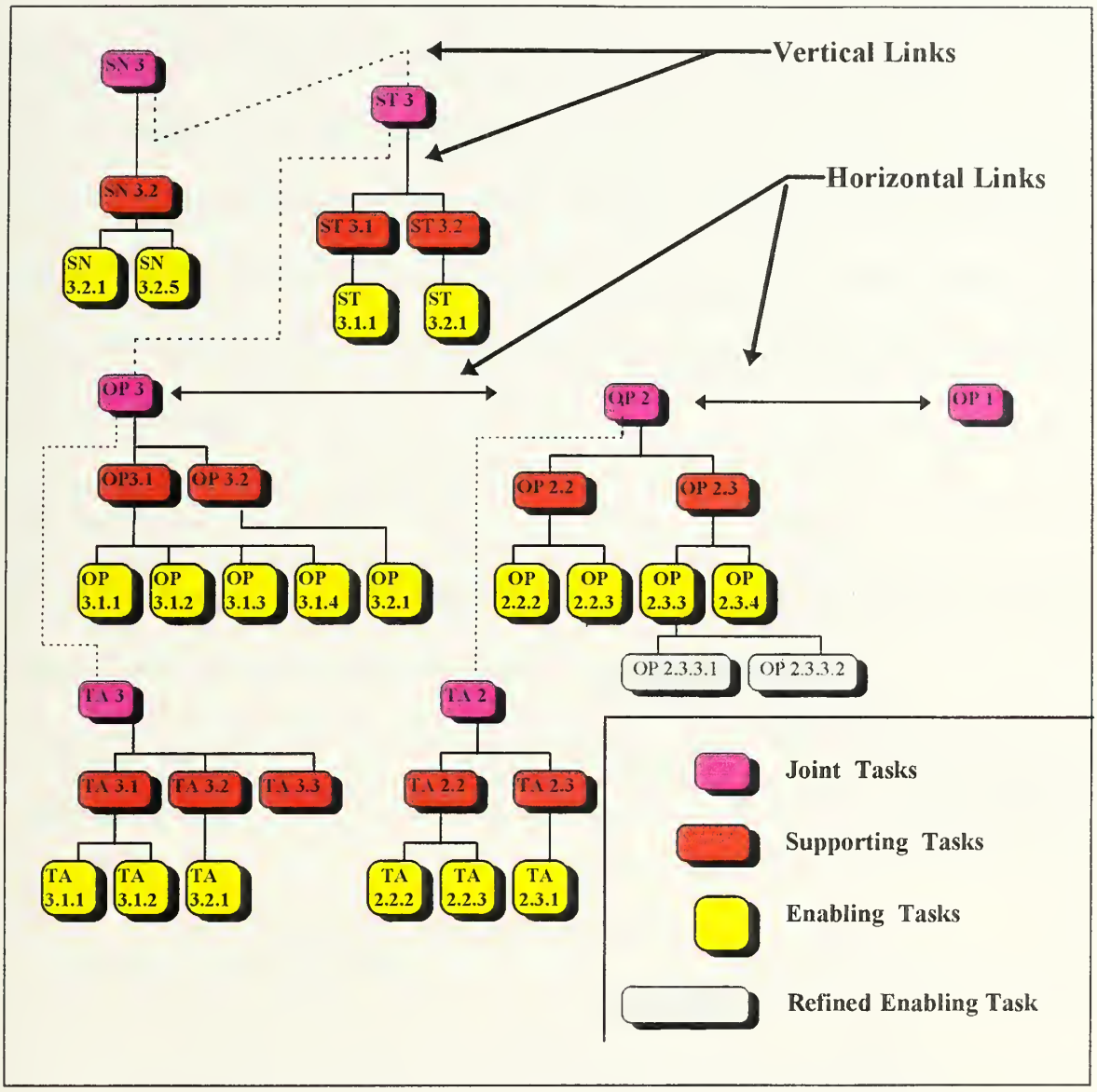

Figure 4. Joint Task Schematic showing Joint Firepower and supporting tasks.

B. CRITICAL EVENTS

To evaluate the CINC staff performance in the execution of operational firepower during the conduct of a CAX, is necessary to create an audit trial to ascertain the causal reasons for any *critical events* that occur during the CAX. For this paper, a critical event

is defined as any event occurring during an exercise that is useful in the post exercise reconstruction for analysis of the effects of operational firepower. Normally, a critical event is viewed as a derogatory event with a less than favorable outcome. For example, a critical event may be the fact that a SCUD missile, designated as a high payoff target, was not shot down and damaged a logistics facility. The causal reasons for this event would be shown through the building of an audit trail. The following example questions could then be answered:

Was the HPT (SCUD) ever detected?
Was any firepower available?
Was the length of time after detection and prior to engaging too great?
Was Battle Damage Assessment (BDA) from previous engagements perceived correctly?

Figure 5 shows the beginning of the critical events audit trail.

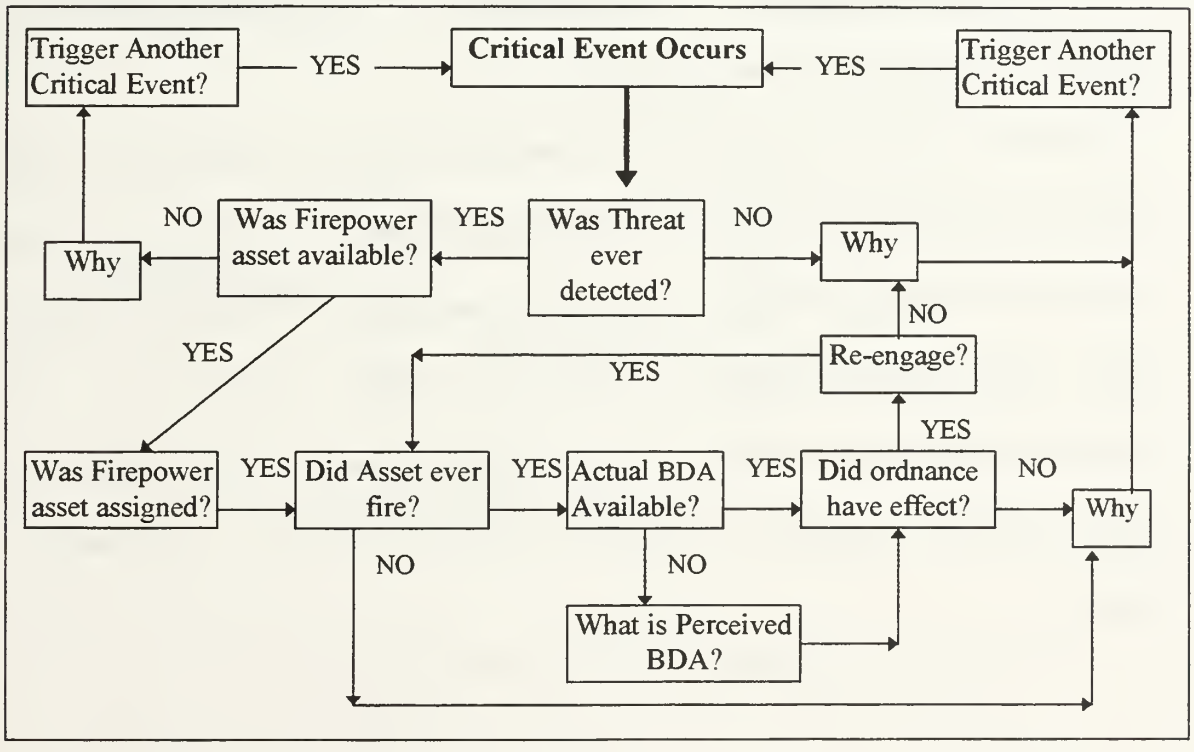

Figure 5. Critical event audit diagram.

C. DENDRITIC

To determine the data requirements for the audit trail, it is necessary to construct a dendritic prior to the running of a CAX. The purpose of the dendritic is to refine task requirements to the point where data explicative of performance can be gathered. The dendritic is formed by focusing on the overall intent of the related joint tasks across levels of war and reformulating it in the form of a question. This question represents the overall issue to be resolved. Likewise, corresponding functional areas form critical subordinate issues that generally reflect the level at which the measures of effectiveness (MOEs) are developed. Specific task requirements within each of the functional areas serve to formulate yet another level of sub-issues that may determine underlying measures of performance (MOPs). Continued refinement of task requirements ultimately leads to the point where data can be gathered.

Data requirements are assumed to be unconstrained by physical mechanisms (i.e. data base sizes, processing times, model resolution, etc.). Furthermore, they may be objective or subjective. Objective data refer to those directly measurable or capturable within the context of the computer simulation. Subjective data include non-measurable or non-quantifiable factors that may stand alone or serve to help qualify observed results. A complete dendritic addressing the issues of operational firepower is illustrated in Figure 6.

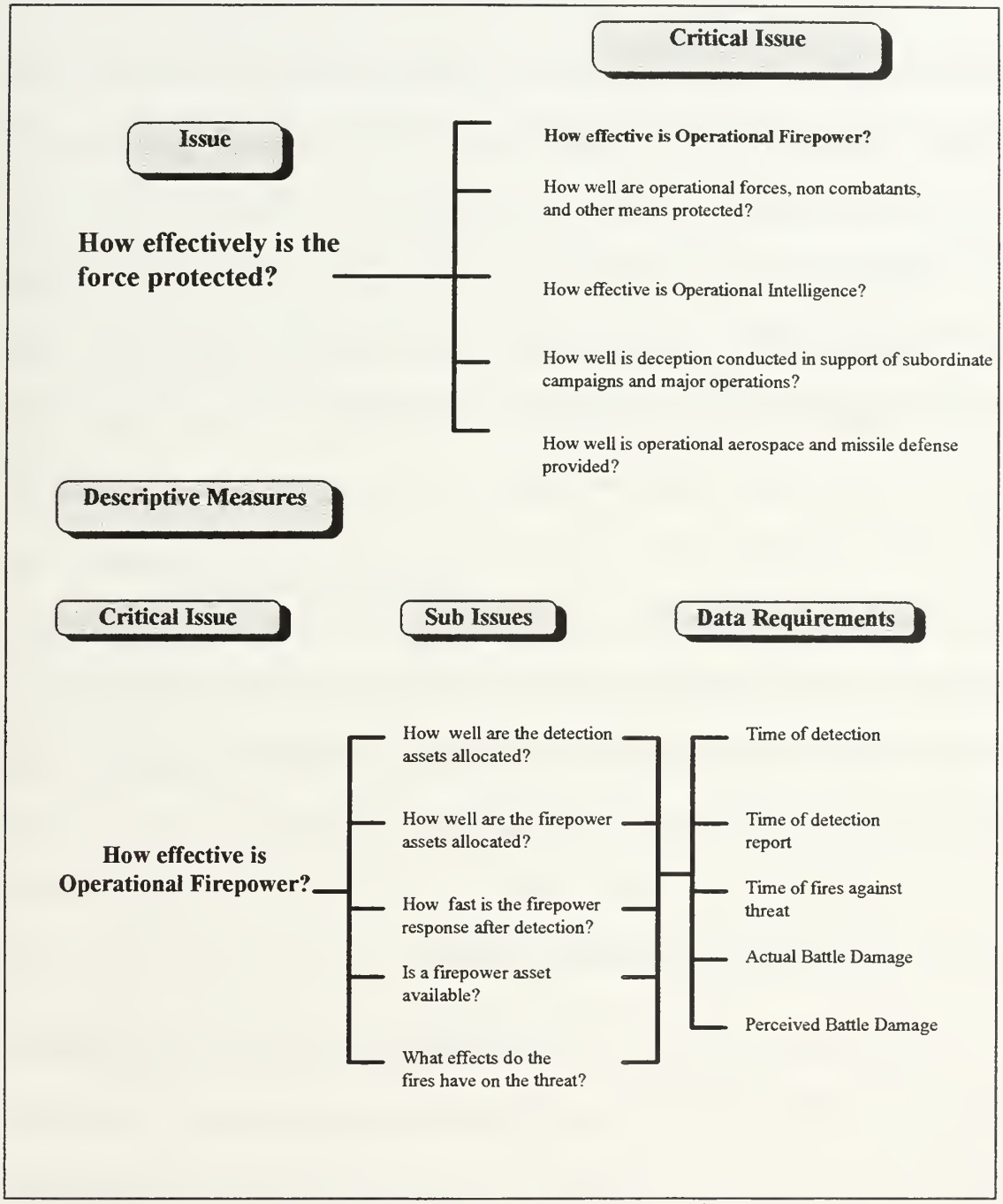
Critical Issue
Issue
How effectively is the force protected?
How effective is Operational Firepower?
How well are operational forces, non combatants, and other means protected?
How effective is Operational Intelligence?
How well is deception conducted in support of subordinate campaigns and major operations?
How well is operational aerospace and missile defense provided?
Descriptive Measures
Critical Issue
Sub Issues
Data Requirements
How effective is Operational Firepower?
How well are the detection assets allocated?
How well are the firepower assets allocated?
How fast is the firepower response after detection?
Is a firepower asset available?
What effects do the fires have on the threat?
Time of detection
Time of detection report
Time of fires against threat
Actual Battle Damage
Perceived Battle Damage

Figure 6. Dendritic for Force Protection.

D. DATA REQUIREMENTS

The dendritic shows the requirement for the detection time, the time the munitions reach the target or engagement time, actual battle damage and perceived battle damage. Normally, there is some delay between detection time and engagement time. This time delay may be due to non-availability of firepower assets, poor communications, time of flight (TOF) of a weapon system, range to the target exceeds that of friendly weapon systems, or possibly another target is of higher priority, hence requiring engagement prior to other detections. Depending on the type of target, a time delay may or may not be a factor with respect to the effects of firepower. If the target has continuous monitoring (i.e. from a forward observer), constant updates on the target's location are given and the effects of munitions are reported almost immediately. These *real time* intelligence updates allow for accurate battle damage assessment (BDA). This information is then used to determine if the target requires re-engagement. In this thesis, real time BDA will be referred to as actual BDA (BDA_{actual}).

1. Perceived Battle Damage Assessment

In the case where a target is not continuously monitored, the time difference between target detection and munitions delivery is crucial. In this case, a CAX player can only estimate the BDA. In this thesis, this type of BDA is considered as perceived BDA. When determining perceived BDA, a person must rely on his knowledge of the enemy forces, proficiency of the weapon system used, and account for the time delay

since the report. This time delay may or may not include a change of enemy location. This difference in location (location error) may result in less than optimal effects of munitions, but more importantly may be the reason for extremely inaccurate perceived BDA. This inaccuracy will most likely affect the decision of whether or not to re-engage the target. Obviously, the accuracy of BDA is essential, particularly where targets are designated as High Payoff Targets (HPT). It is easy to see how perceived BDA will most likely vary from person to person. This report shows how perceived BDA can be estimated in a CAX without ambiguity between persons and enhance the effectiveness of firepower.

2. Intelligence Report Score

This paper utilizes the *intelligence report scoring* concept from Towery 95 [Ref. 8] to show how target location error can be predicted and aid in the effectiveness of firepower. Towery shows how the report score (RS) given in equation (1) can provide a measure of how effective a CINC's intelligence staff was at providing valuable information on "other than friendly units" (OTFUs) with only limited assumptions as to the structure of the decay of the value of the information as it ages.

$$\text{Report Score (t)} = (\sum_{l} w_{l,i,j(t)})/3 \qquad (1)$$

where

$w_{l,i,j(t)}$ - A utility weighting factor from 0 to 1 of the depreciation of intelligence data as a function of intelligence report element type, other than friendly unit type, and age.

indices:

i - Other than friendly Unit { 1st Rep Guard, 2nd Artillery Battalion...}
t - time { in integer hours from the start of the CAX t = 1,2,3...}
j(t) - age of last intelligence update
l - intelligence report element type {location, estimate COA, strength }

Towery suggests three possible functional forms, borrowed from the study of economics, to express the manner in which intelligence information may be perceived to depreciate. These three depreciation functions are not meant to capture every possible structure for which information value will depreciate but to provide a sound starting point in the development of utility weighting functions for the value of intelligence information [Ref. 8].

$$w(t) = -\alpha t + 1 \text{ and } 0 \text{ at } \alpha t \geq 1 \quad \text{for } 0 \leq \alpha \leq 1,\ t \geq 0, \tag{2}$$

$$w(t) = -(1-\alpha)^t \text{ for } 0 \leq \alpha \leq 1,\ t \geq 0, \tag{3}$$

$$w(t) = 1 - 1/(1+\beta e^{-\alpha t}) \text{ for } 0 \leq \alpha \leq 1,\ \beta \geq 0,\ t \geq 0, \tag{4}$$

Where

α and β are parameters fitted from data.
t = time.

Figure (7) provides sample curves for the three functions given above with specific parameters values.

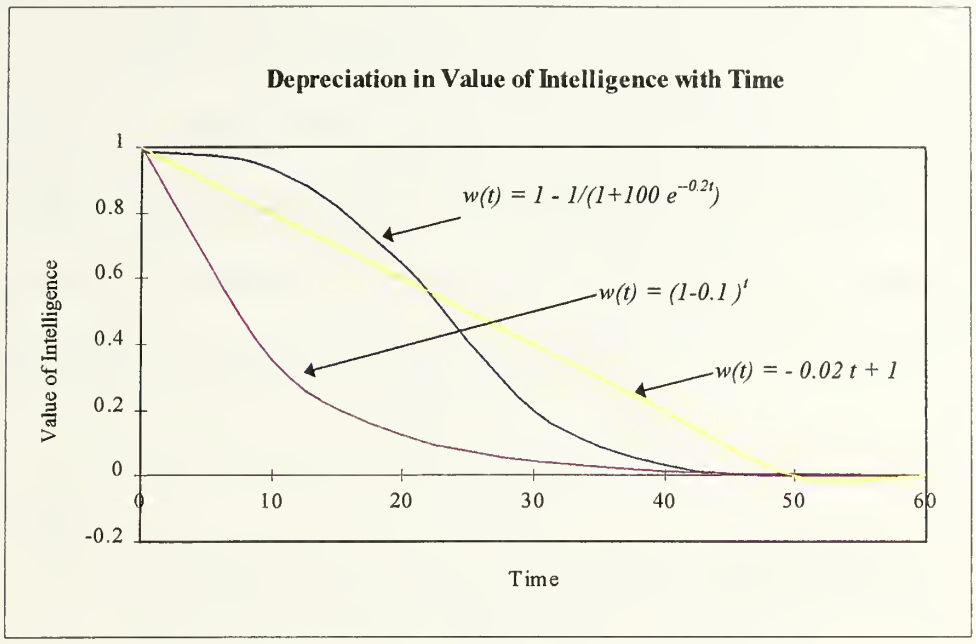

Figure 7. Depreciation of intelligence value with time.

One can easily see how the value of intelligence depreciates over time using this methodology. Similarly, when a detected target is moving or likely to move, one can also expect to see a possible degradation in the effects of firepower if the munitions do not arrive at the detected location in a timely manner. By amending Towery's intelligence report scoring and using these formulas, report scores may be used as possible surrogates for location error. Once location error is determined, perceived BDA can be calculated and made available to a player of a CAX immediately upon completion of engaging a target. This information can then be used to determine the need for possible re-engagement.

3. Target Location Report Score

Modifying Towery's intelligence report scoring into equation (5), it is possible to create a Location Report Score (LRS). The LRS is the value of the RS at the time of munitions impact. Therefore, the LRS relates to the relative position of the target at the time of impact *after the initial detection was reported.*

$$LRS_i(t) = (\sum w_{l,i,j(td+\Delta t)})/3 \quad (5)$$

where

$w_{l,i,j(t)}$ - A utility weighting factor from 0 to 1 of the depreciation of intelligence data as a function of intelligence report element type, other than friendly unit type, and age.

indices:

i - Other than friendly Unit { 1st Rep Guard, 2nd Artillery Battalion...}

t - time { in integer hours from the start of the CAX t = 1,2,3...}

t_d - time of detection

Δt - time difference between the initial detection and the engagement of the target

l - intelligence report element type {location, estimate COA, strength }

Figure 8 shows an example of a depreciation function with an hypothetical time delay (Δt = 20 time units) between the initial detection and engagement of the target.

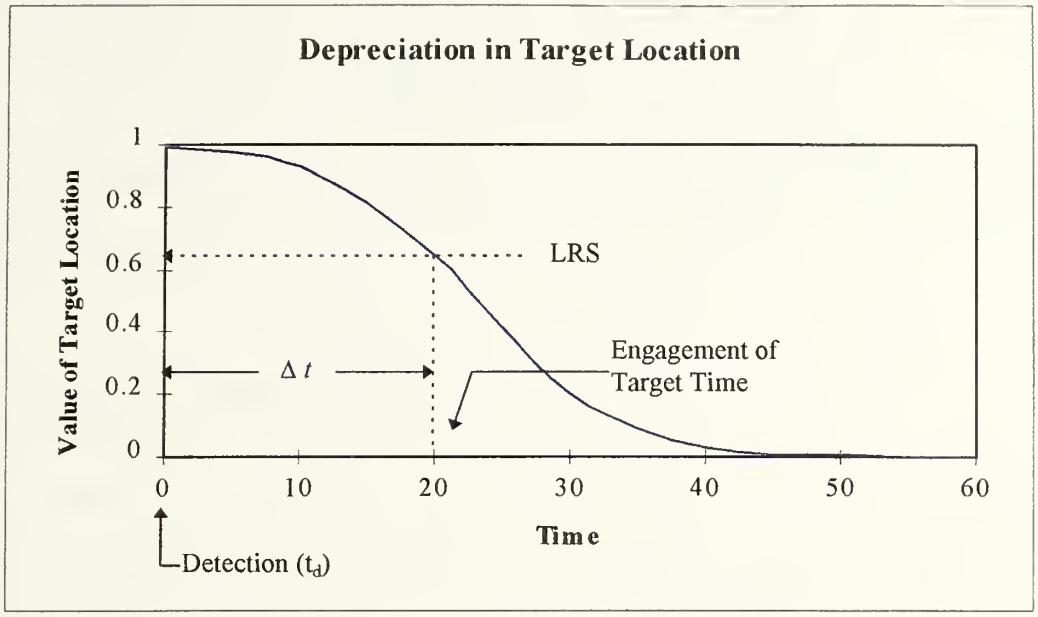

Figure 8. Depreciation of Location with time.

If there is no time delay ($\Delta t=0$) then RS = LRS with respect to the value of intelligence and the relative position of the target at the time of impact. In this case, the player can expect to achieve the best effects on the target based on the weapon system used and the size of the target. These effects would then give the best expected battle damage assessment (BDA_E) possible. It is reasonable to assume that the player knows what these best effects would be, given these known parameters.

Once the LRS is ascertained, perceived BDA (BDA_p) can easily be computed as shown in equation (6).

$$BDA_p = LRS*BDA_E \tag{6}$$

Using Figure (8) as an example, note that $\Delta t = 20$ relates to an LRS of 0.63. If BDA_E was computed to be 50 targets, then BDA_P would be:

$$BDA_p = LRS * BDA_E$$
$$BDA_p = 0.63 * 50$$
$$BDA_p = 31.5 \text{ Targets.}$$

If BDA_p is equivalent to BDA_{actual}, then the LRS curve used is valid to report BDA against these targets.

E. LOCATION REPORT SCORE CURVES

Obviously, using the correct depreciation curve is important to ascertain accurate BDA. For example, detected aircraft on an enemy airfield have the ability to move rapidly, quickly degrading the value of their reported location. This type of target may have a more exponential type depreciation curve, whereas detected supply ships docked in a port do not have the ability to leave the port rapidly, resulting in a very slow depreciation of the location value. Similarly, a unit detected while moving over easily maneuverable terrain may have an approximately linear curve to ascertain the LRS, while a stationary unit likely to move after being detected may have more of a gradual sloping curve. Figure 9 shows four suggested curves that can be applied to these target types.

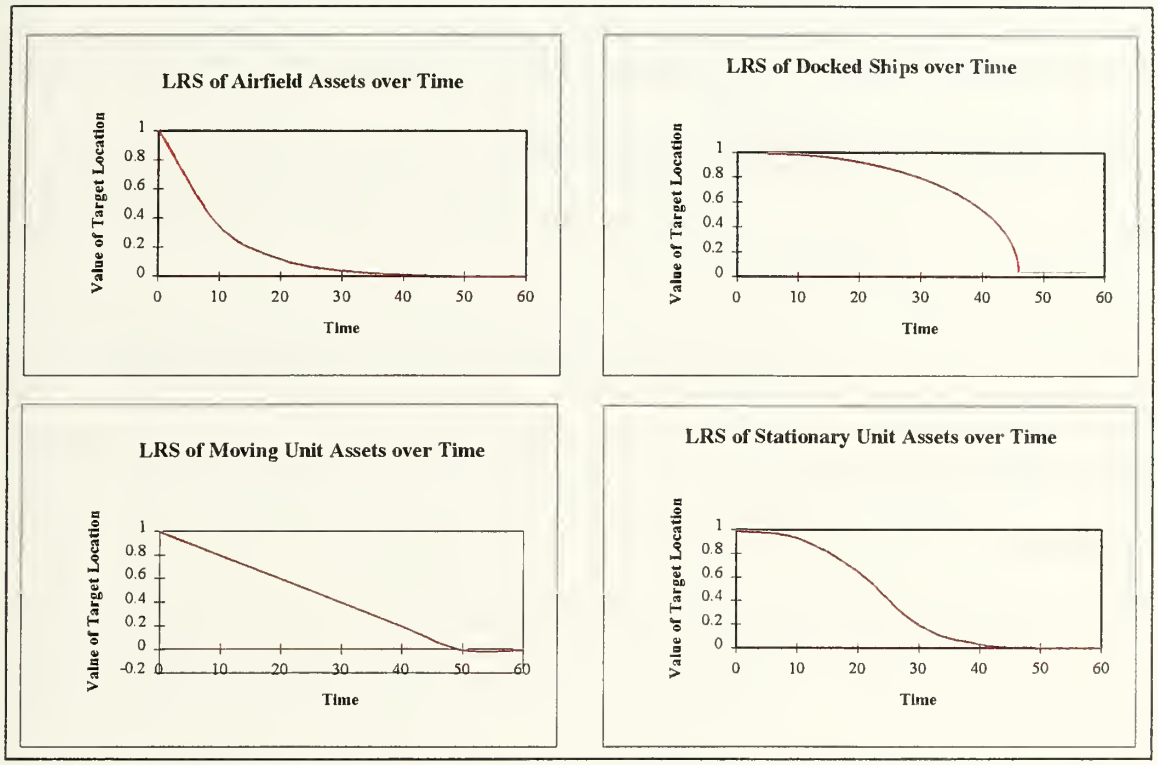

Figure 9. Four different target types and their associated Location Report Score (LRS) curves.

IV. APPLICATION

This chapter demonstrates an application of the methodology for evaluating the effectiveness of operational firepower as described in Chapter III using a computer model currently in use for the training of CINC staffs. Specifically, it shows how, with minimal planning prior to the onset of a CAX, a simulation model can furnish perceived battle damage assessment necessary to provide greatly enhance firepower effectiveness. It is important to emphasize that this experiment was not intended to demonstrate tactics nor to evaluate the performance of the computer model.

A. JOINT THEATER LEVEL SIMULATION (JTLS)

The Joint Theater Level Simulation (JTLS) is an interactive, multi-sided, joint (air, land, naval, and special operations) and combined (coalition warfare) constructive simulation model. It is used for both operational planning and training support. This computer based wargaming system uses inherent functions – sea, air, land, special operations, intelligence and logistics to model conflict (pre-combat, combat operations and post combat) at the operational level of war with tactical fidelity. The Joint Warfighting Center is the joint sponsor of JTLS and has used JTLS as the exercise driver for several previous combined exercises. For example, JTLS was used as the exercise driver for the combined exercise Keen Edge 94 in support of U.S. Forces and Japan's Joint Self-Defense Forces, and for a combined U.S. Thailand exercise, Cobra Gold 95.

The data base for this study was adapted from a modified Desert Storm scenario. Routines for capturing the parameters required to implement the methodology were developed by Rolands and Associates Inc., the primary contractor of JTLS. Specifically, data capturing the actual damage to targets were sent to the post processor engagement file which was in standard ASCII format that was easily read into a commercial spreadsheet package, Microsoft® Excel. A sample spreadsheet of these files is contained in the Appendix.

B. SCENARIO DESCRIPTION

To apply the specific methodology, three enemy units were created in the data base. Specific target types and numbers were added to these units. These target types were the Soviet made ZSU, an anti-air artillery weapon, and the hand-held SA7 (Grail), an anti-air missile. These targets were designated as HPTs and engagement data were collected on them. Again, these target types and their associated numbers were formulated to demonstrate the methodology and may not be representative of an actual combat organization of these units.

1. ZSU Target

Each unit was given different numbers of ZSU batteries for sensitivity analysis. However, in all scenarios, each ZSU battery had nine launchers. Additionally, in all scenarios the ZSU battery covered an area with a radius of 56 meters.

2. SA7 Target

Each unit was given a total of fifteen SA7 weapons. All 15 weapons were contained in a radius of 150 meters. These numbers remained the same for all three scenarios.

3. Scenario A

In this scenario all three units were given the same radius (1000 meters). However, the number of ZSU batteries was different in each unit: Unit A received eight (8), Unit B received five (5), and Unit C received two (2). Since each ZSU battery contains nine (9) launchers, the actual number of launchers per unit was 72, 45 and 18, respectively. The probability of kill against a ZSU launcher given that it is hit (Pkill | Hit) remained constant at 0.37. Again, the number of SA7 weapons was set at fifteen (15) per unit with a (Pkill | Hit) of 0.83 on each weapon. The actual JTLS computation of Pkill is discussed later in this chapter.

4. Scenario B

In Scenario B, the number of ZSU batteries was held constant at five (5) per unit, resulting in a total of 45 launchers per unit. A change was made in the radius of the units: 700 meters for Unit A, 1000 meters for Unit B, and 1300 meters for Unit C. No change was made to the SA7 weapons or to the Pkill data.

5. Scenario C

This scenario closely resembles Scenario B except for a change in the Pkill data per target type. Pkill for the ZSU targets was set to 0.60 and to 0.97 for the SA7 targets. All other parameters were the same as in Scenario B.

The firepower assets used to attack the units in all cases was the Multiple Launch Rocket System (MLRS) weapon system. However, the Pkill generated from this weapon system can be considered generic and may be associated with other types of operational firepower assets. The difference in the Pkill can be considered as different types of friendly firepower assets or the same asset with a change in the number of munitions fired. Table 1 shows the three scenarios used in the application of the methodology.

SCENARIO A

UNIT	UNIT RADIUS	NUMBER ZSU's	Pkill Lethality (ZSU)	NUMBER SA7	Pkill Lethality (SA7)
A	1000	8	0.37	15	0.83
B	1000	5	0.37	15	0.83
C	1000	2	0.37	15	0.83

SCENARIO B

UNIT	UNIT RADIUS	NUMBER ZSU's	Pkill Lethality (ZSU)	NUMBER SA7	Pkill Lethality (SA7)
A	700	5	0.37	15	0.83
B	1000	5	0.37	15	0.83
C	1300	5	0.37	15	0.83

SCENARIO C

UNIT	UNIT RADIUS	NUMBER ZSU's	Pkill Lethality (ZSU)	NUMBER SA7	Pkill Lethality (SA7)
A	700	5	0.60	15	0.97
B	1000	5	0.60	15	0.97
C	1300	5	0.60	15	0.97

Table 1. Description of Three Scenarios used to apply the Methodology.

In each scenario, following initial detection of the units and without a change in their location, they were engaged by the firepower asset. This engagement simulated a time delay of zero ($\Delta t = 0$). Following this initial engagement the units were restored to their original strength and started moving along their pre-designated routes. After a time elapse of one minute, the units were again engaged without change to the method of delivery. The impact of the weapon effects remained at the original detection location, thereby simulating a one minute time delay between unit detection and engagement. Again, the units were restored to their original strength and continued to move. This process was repeated until the entire unit was outside of the weapons effect area. Each time the units were engaged, the model captured the data in an ASCII engagement file. Figure 10 depicts an example of a unit moving while the weapon effects impact location remains the same. It is important to recall that the definition of Δt is the time difference

between detection and engagement. For each engagement, each target is stochastically placed within the area of its parent unit. For example, the 8 ZSUs in Unit A were randomly placed within Unit A at each time step. This stochastic placement is a major factor when the unit area is larger than the weapons effects area, when there is partial overlap with unit and weapons effects, or both.

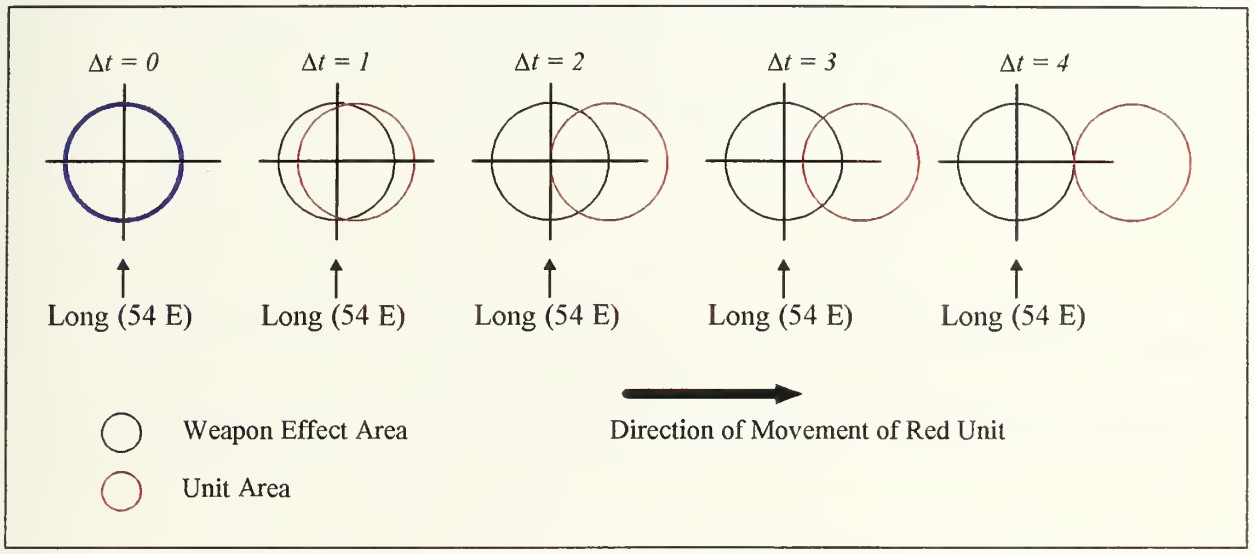

Figure 10. Depiction of a moving target showing the difference in affected area of the weapon based on the time difference (Δt) between the detection time and the engagement time.

C. DAMAGE TO TARGETS

To develop the methodology, it is important to understand how the JTLS model calculates area damage to targets. For targets types, the distance between the impact point and the target center is computed and one of the following four cases can exist.

1. Case One

The weapon effects radius is larger than (or equal to) the target radius. In this case, only some fraction of the weapon munitions fired have an effect, but the entire target is affected. The number of weapon munitions that have an effect is then used to determine the Pkill against the elements within the target. A special case arises when the target location and impact point are collocated and the radii are identical. In that case, all weapons are effective and the whole target is at risk.

2. Case Two

The target radius is larger than the weapons effects radius and the weapons effects are completely enclosed within the target radius. In this case, all the weapon munitions are effective but only a part of the target is at risk.

3. Case Three

The weapons radii are larger than the target radius and there is partial overlap. First, the same probability of kill associated with the target in Case (1) is determined. Second, a uniform draw between zero and one determines the fraction of the target covered. This fraction is then multiplied by the Case (1) probability of kill to determine a new probability of kill against the elements within the target. In this case only a fraction of the munitions are effective, but they may cover all or part of the target.

4. Case Four

The target radius is larger than the weapons effects radius and there is partial overlap. In this case, the effects fraction is computed as the Weapons Area/Target Area, and a uniform draw between zero and the effects fraction determines the fraction of the target area that is covered. That fraction, multiplied by the effects fraction, is the fraction of the rounds that were effective. In this case, a fraction of the rounds always affects a fraction of the target.

An illustration of the four possible cases of weapons effects against a target is shown in Figure 11.

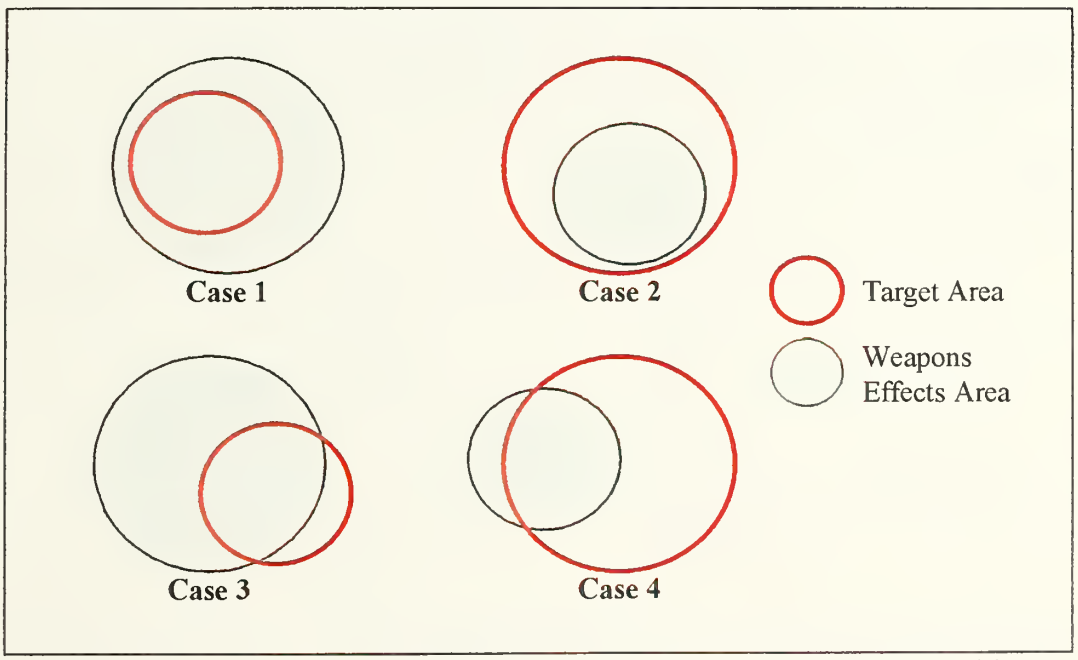

Figure 11. Four cases showing how targets are affected by weapons munitions.

D. PROBABILTY OF KILL (P_{KILL})

In each scenario the weapon effects adius remained constant at 1000 meters. Since the battery radius is 56 meters in all three scenarios, either Case (1) or Case (3) was used to determine the Pkill for each entity (launcher) within the battery. It is important to mention that the difference in size of the *unit* radius is only a factor in the stochastic placement of the batteries throughout the unit. The calculation of Pkill for the batteries is based solely on the relationship of the battery location to the weapon effects impact location. The equation used by JTLS to determine Pkill is:

$$\text{Pkill} = 1 - \exp\left(-NR_t * \frac{LA}{CA}\right) \tag{7}$$

Where:

NR_t = Number of Rounds in the battery area
CA = Covered Area (Area of the battery covered by the effects)
LA = Lethal Area for particular Weapon type, Target type

The parameters for Scenario "A" are used to show an example derivation of Pkill. The additional nomenclature with their respective values is as follows.

Ri (Radius of Impact)	= 1000 m	
Rt (Radius of Battery)	= 56 m	
NR (Number of Rounds Fired)	= 180 rds	
At (Area of Battery)	= Pi * (Rt) ^2	= 9852 m 2
Aw (Area of Weapons effects)	= Pi * (Ri) ^2	= 3141596 m 2
LA (Lethal Area)	= 8000 m ^ 2	
CA (Covered Area)	= 9852 m ^ 2	

With the data given, equation (8) is used to compute the number of rounds that impact in each battery area (NR_t).

$$NR_t = \frac{A_t}{A_w} * NR = \frac{9852\,m^2}{3141596\,m^2} * 180\,rds = 0.56\,rds \tag{8}$$

Once NR_t is determined, the Pkill for each target is calculated using equation (7).

$$\text{Pkill} = 1 - \exp\left(-0.56 rds * \frac{8000 m^2}{9852 m^2}\right) = 0.37$$

Once the Pkill value is determined, a Monte Carlo draw is conducted for each launcher in the battery. For example, since there are nine launchers per ZSU, nine U(0, 1) draws are conducted. For each number drawn that is less than or equal to 0.37, a launcher is destroyed.

In the case where the target area is smaller than the weapons effect area and there is an overlap (Case 3), then the first U(0,1) drawn is multiplied by the Pkill (in our example 0.37) to obtain a new Pkill. The Monte Carlo draw is then matched against this new Pkill to determine the number of launchers killed.

E. EXPECTED BDA

The expected BDA (BDA_E) can be computed after the Pkill is determined. Again, using Scenario "A", where unit A has 8 ZSU batteries each having 9 launchers, a total of 72 launchers are present. BDA_E is computed by multiplying the total number of launchers in the unit by the Pkill. This number will give the expected number of launchers killed. In the Scenario "A" example, BDA_E equals 26.64 or approximately 27 launchers. Equation (9) is used to compute expected BDA.

$$BDA_E = Pkill * \sum_{i=1}^{T} L_i \quad (9)$$

Where:

T = Total number of Targets

L_i = Total number of Launchers in Target i

F. RESULT FOR ACTUAL BDA (BDA ACTUAL)

Table 2 shows data obtained from one run of each of the three scenarios. Figures 12 through 14 show graphical representations of actual BDA as the time between target detection and target engagement increases. Using Figure 13 as an example, a noticeable increase is seen in actual BDA at $\Delta t = 4$ and $\Delta t = 6$ (Scenario C) and at $\Delta t = 6$ and $\Delta t = 9$ (Scenario B). This increase may be the result of the stochastic placement of the targets throughout the unit at those time intervals allowing for a target to be missed all together, resulting in a Pkill equal to zero for that target. Another possible reason for the increase may simply be that the U(0,1) draw did not produce a value less than or equal to the determined Pkill. However, over the entire range in both scenarios the trend for actual BDA is decreasing.

		UNIT "A" (Radius 1000 M)		UNIT "B" (Radius 1000 M)		UNIT "C" (Radius 1000 M)	
	Delta (T)	BDA (Actual)		BDA (Actual)		BDA (Actual)	
	(min)	ZSUs	SA7	ZSUs	SA7	ZSUs	SA7
	0	23	13	14	12	3	12
SCENARIO A	1	26	12	15	10	9	13
Pk (ZSU) = 0.37	2	26	12	7	9	0	2
Pk (SA7) = 0.83	3	26	12	18	12	4	10
	4	28	0	12	11	4	14
	5	22	15	14	0	4	0
	6	24	13	12	0	0	0
	7	15	12	2	4	0	0
	8	17	0	3	0	0	0
	9	19	0	11	0	0	0
	10	5	0	0	0	0	0
	11	4	0	4	0	0	0
	12	7	4	0	0	0	0
	13	3	0	0	0	0	0
	14	3	0	0	0	0	0
	15	4	0	0	0	0	0
	16	1	0	0	0	0	0
	17	0	0	0	0	0	0
		UNIT "A" (Radius 700 M)		UNIT "B" (Radius 1000 M)		UNIT "C" (Radius 1300 M)	
	Delta (T)	BDA (Actual)		BDA (Actual)		BDA (Actual)	
	(min)	ZSUs	SA7	ZSUs	SA7	ZSUs	SA7
	0	15	12	12	12	3	12
SCENARIO B	1	19	15	21	11	9	4
Pk (ZSU) = 0.37	2	19	13	15	13	12	2
Pk (SA7) = 0.83	3	14	12	10	12	11	12
	4	12	14	6	0	14	0
	5	9	11	18	10	8	9
	6	11	11	15	10	9	0
	7	5	0	0	7	4	13
	8	0	0	5	13	5	0
	9	3	0	0	0	0	0
	10	0	0	2	0	0	0
	11	0	0	0	0	0	0
		UNIT "A" (Radius 700 M)		UNIT "B" (Radius 1000 M)		UNIT "C" (Radius 1300 M)	
	Delta (T)	BDA (Actual)		BDA (Actual)		BDA (Actual)	
	(min)	ZSUs	SA7	ZSUs	SA7	ZSUs	SA7
	0	26	14	25	14	6	15
SCENARIO C	1	26	15	26	14	18	7
Pk ZSU = 0.60	2	24	15	34	15	14	1
Pk SA7 = 0.97	3	18	15	32	1	11	15
	4	19	15	4	0	16	0
	5	6	14	21	0	12	11
	6	8	0	5	15	16	0
	7	0	0	6	0	18	0
	8	0	0	0	0	0	0
	9	0	0	0	0	5	0
	10	0	0	0	0	0	0

Table 2. Data from one run of each scenario showing the actual number of targets desroyed at each Δt.

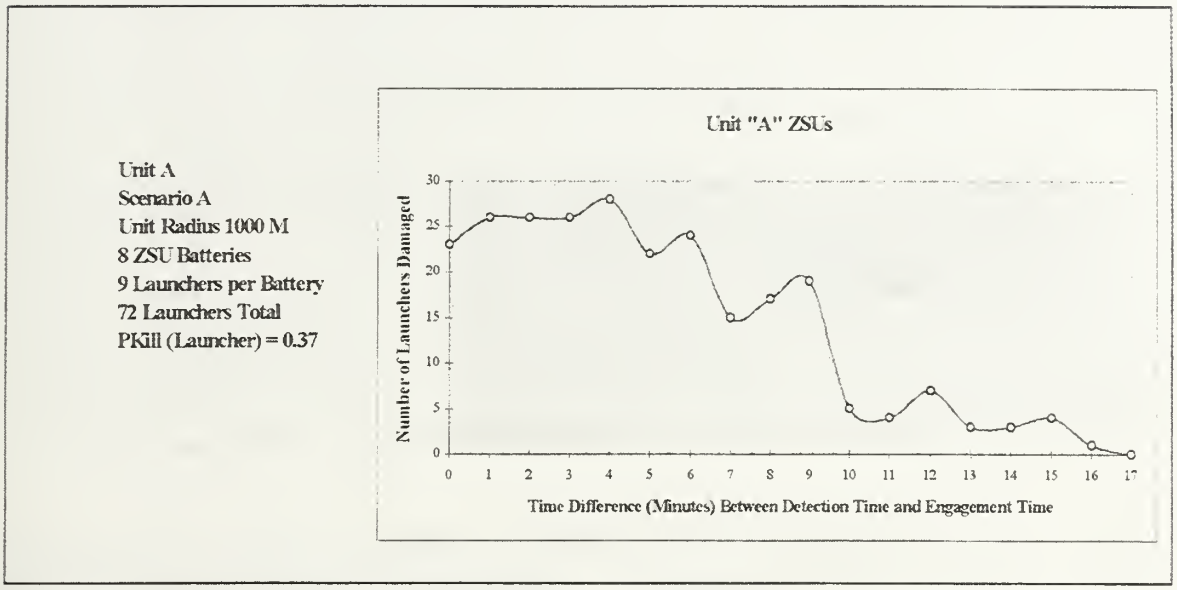

Figure 12. Unit A of Scenario A showing total number of ZSU launchers damaged at each time difference. All 72 Launchers are available at each time interval.

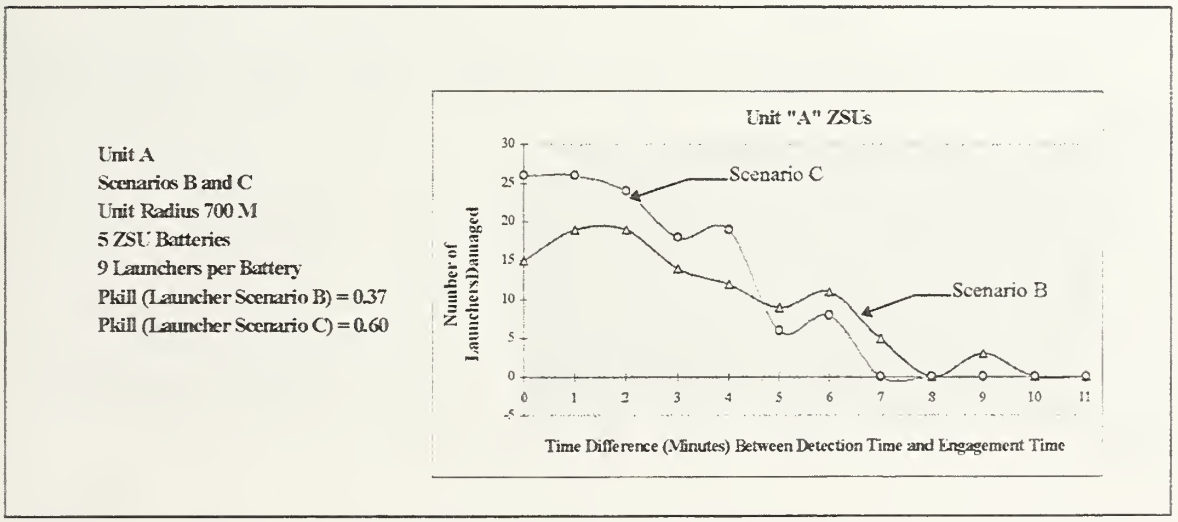
Unit A
Scenarios B and C
Unit Radius 700 M
5 ZSU Batteries
9 Launchers per Battery
Pkill (Launcher Scenario B) = 0.37
Pkill (Launcher Scenario C) = 0.60
Unit "A" ZSUs
Scenario C
Scenario B
Number of LaunchersDamaged
Time Difference (Minutes) Between Detection Time and Engagement Time

Figure 13. Unit A in Scenario B and C showing total number of ZSU launchers damaged at each time difference. All 45 Launchers are available at each time interval for both scenarios.

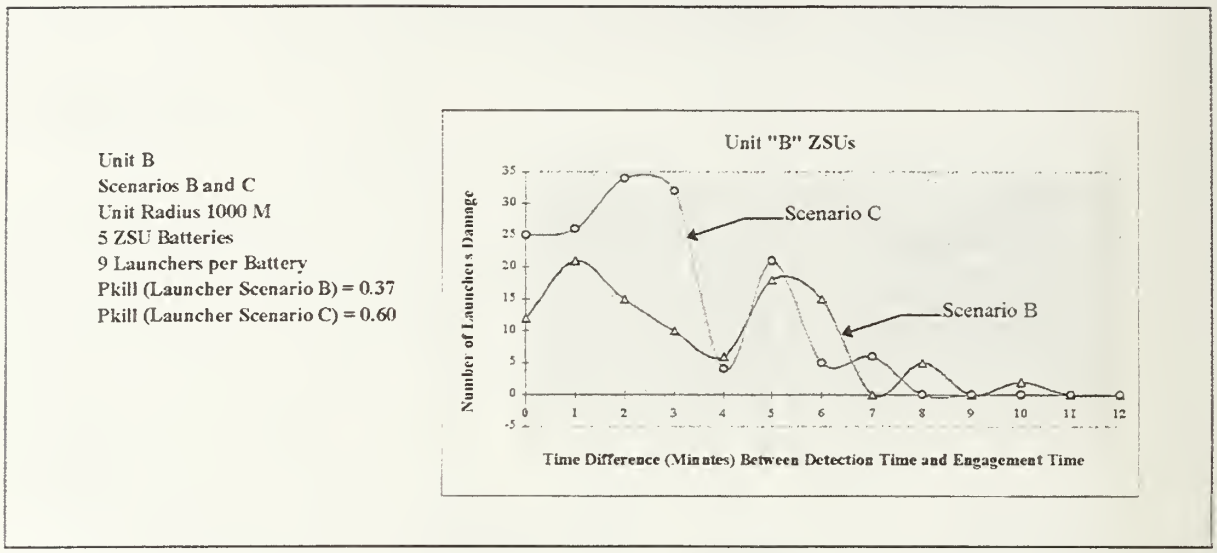
Unit B
Scenarios B and C
Unit Radius 1000 M
5 ZSU Batteries
9 Launchers per Battery
Pkill (Launcher Scenario B) = 0.37
Pkill (Launcher Scenario C) = 0.60
Unit "B" ZSUs
Scenario C
Scenario B
Number of Launchers Damage
Time Difference (Minutes) Between Detection Time and Engagement Time

Figure 14. Unit B of Scenario B and C showing total number of ZSU launchers damaged at each time difference. All 45 Launchers are available at each time interval for each scenario.

G. LOCATION REPORT SCORE APPLICATION (PERCEIVED BDA)

Once the value of the target location is generated, perceived BDA (BDA_p) can be determined as explained in Chapter III. Two Location Report Score functions are presented here (Figure 15) to show the application of the methodology. LRS #1 (equation 10) is essentially one minus a logistic function with its parameters, α and β, set at 0.50 and 100, respectively. LRS #2 (equation 11) is the exponential depreciation function with the decay rate parameter, α, set to 0.25.

$$w(t) = 1 - 1/(1+ 100\, e^{0.50t}) \quad (10)$$

$$w(t) = (1-0.25)^t \quad (11)$$

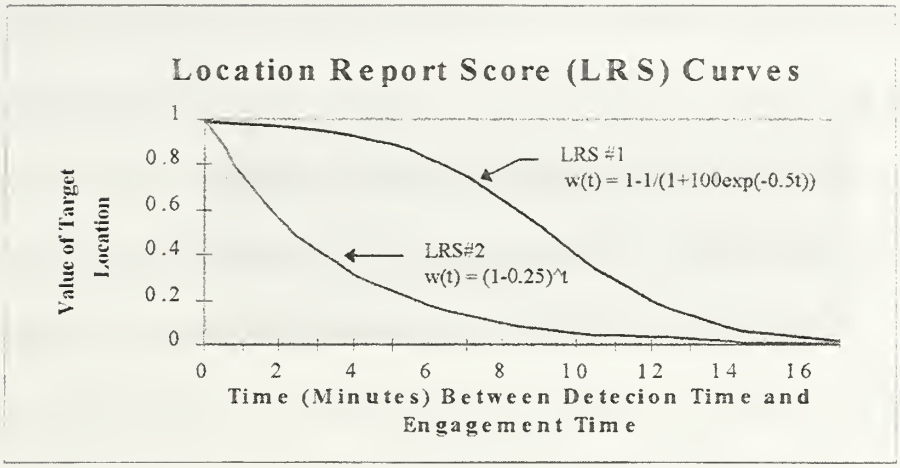

Figure 15. LRS Curves for computing Perceived BDA.

H. COMPARISON OF ACTUAL BDA AND PERCEIVED BDA

Table 3 shows the comparison of perceived BDA, generated from the depreciation functions above, and actual BDA taken from scenario "A", unit "A" (Table 2). Column D is the expected BDA determined from equation (9). Columns E and F show the perceived BDA data from LRS #1 and LRS #2, respectively. Data in Columns H and I are the difference of perceived BDA values and actual BDA values (Column G). There is a noticeable distinction between the magnitude of the values in Column H and those in Column I. In other words, the values generated from LRS #1 are much closer to the actual BDA values, making LRS#1 the better curve to report perceived BDA for this target type.

In this example only the data generated from Scenario "A", Unit "A" were used. The ideal curve was determined by applying the methodology to the two LRS curves with specified parameters. The optimal application of the methodology is to produce

numerous runs, with a combination of parameter values, then fit the best curve to the data. Once this curve is determined, its formula with associated parameters can be programmed into the simulation model. This would be done for all target types frequently assigned as HPTs. It is necessary to include in the algorithm the ability for the model to display the perceived BDA value to the player once an engagement takes place. With this capability, a CAX player can determine if a target requires immediate re-engagement, an intelligence update or no further action.

A	B	C	D	E	F	G	H	I
Delta (T)	LRS #1	LRS #2	E(BDA)	BDAp (LRS #1)	BDAp (LRS#2)	BDA (actual)	Diff LRS#1	Diff LRS#2
0	0.9901	1.0000	27	27	27	23	4	4
1	0.9838	0.7500	27	27	20	26	1	-6
2	0.9735	0.5625	27	26	15	26	0	-11
3	0.9571	0.4219	27	26	11	26	0	-15
4	0.9312	0.3164	27	25	9	28	-3	-19
5	0.8914	0.2373	27	24	6	22	2	-16
6	0.8327	0.1780	27	22	5	24	-2	-19
7	0.7512	0.1335	27	20	4	15	5	-11
8	0.6468	0.1001	27	17	3	17	0	-14
9	0.5263	0.0751	27	14	2	19	-5	-17
10	0.4026	0.0563	27	11	2	5	6	-3
11	0.2901	0.0422	27	8	1	4	4	-3
12	0.1986	0.0317	27	5	1	7	-2	-6
13	0.1307	0.0238	27	4	1	3	1	-2
14	0.0836	0.0178	27	2	0	3	-1	-3
15	0.0524	0.0134	27	1	0	4	-3	-4
16	0.0325	0.0100	27	1	0	1	0	-1
17	0.0199	0.0075	27	1	0	0	1	0

Table 3. Application of two Location Report Scores showing the difference in computer generated Perceived BDA and Actual BDA.

I. SUMMARY

This chapter has demonstrated through the use of small, illustrative examples how the methodology described in Chapter III can be applied. This methodology is intended

to show how the player during a CAX can improve the operational firepower effectiveness. Due to time constraints only one realization of this methodology was run. With additional runs as described in the previous section, this methodology could be applied to ascertain a LRS for many target types, thereby creating a data base of targets to estimate perceived battle damage assessment.

V. SUMMARY AND RECOMMENDATIONS

A. SUMMARY

This research has provided an exercise analysis methodology for evaluating the effectiveness of operational firepower functions during a computer aided exercise. This methodology includes structuring related joint tasks of the UJTL and developing issues related to performance data requirements. Specifically addressed is the link between intelligence tasks (detection) and firepower tasks (deliver) and the processing of High Payoff Targets (HPTs). This methodology shows how, with planning prior to the start of a CAX, a simulation model can provide perceived battle damage assessment necessary to enhance firepower effectiveness.

Specific to this methodology is the use of the Location Report Score (LRS). The LRS is proposed as a surrogate for target location error and can be used to predict perceived battle damage assessment. The first step in this methodology is to determine the Location Report Score curves needed to engage predetermined High Payoff Targets. One strength of this methodology is that it is relatively uncomplicated but retains the robustness necessary to be applicable in many different exercise scenarios with different types of theater level models. This information can be presented to a player during a CAX to improve firepower effectiveness.

B. RECOMMENDATIONS

Chapter IV discusses how JTLS calculates area damage to targets. In the two cases where there is partial overlap (Cases 3 and 4), a U(0,1) is drawn to determine the fraction of target covered. The calculation for this overlap area is easily computed and could be used instead of the U(0,1) draw.

The key to implementation of this methodology is the determination of the Location Report Scores described in Chapter III. Through the use of simulation it is possible to develop a library of depreciation curves which correspond to the target location error for specific units and targets. This type of library is essential to incorporate into the model prior to the onset of an exercise. With this enhanced data base, the link between operational intelligence and operational firepower would improve, both joint tasks would become more effectively implemented and a more realistic exercise would be the result.

APPENDIX

The report below is a sample of the JTLS output data imported directly into Microsoft Excel for application of the perceived battle damage assessment as discussed in Chapter IV.

Time	Eng Type	Shooter	Weapon	#Rds	Lat	Long	Victim	ObjectDam	NameObj	AmountDam
0.0701389	Controller	Controller	DPICM-MLR	180	31.8111	41.5567	ZSU-23	SAM_AAA	Launcher	3
0.0708333	Controller	Controller	DPICM-MLR	180	31.8111	41.5567	ZSU-23	SAM_AAA	Launcher	4
0.0722222	Controller	Controller	DPICM-MLR	180	31.8111	41.5567	ZSU-23	SAM_AAA	Launcher	2
0.0729167	Controller	Controller	DPICM-MLR	180	31.8111	41.5567	ZSU-23	SAM_AAA	Launcher	3
0.0736111	Controller	Controller	DPICM-MLR	180	31.8111	41.5567	ZSU-23	SAM_AAA	Launcher	3
0.0743056	Controller	Controller	DPICM-MLR	180	31.8111	41.5567	ZSU-23	SAM_AAA	Launcher	5
0.0701389	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID	SAM_AAA	Launcher	2
0.0708333	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID	SAM_AAA	Launcher	4
0.0715278	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID	SAM_AAA	Launcher	2
0.0722222	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID	SAM_AAA	Launcher	3
0.0729167	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID	SAM_AAA	Launcher	3
0.075	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID	SAM_AAA	Launcher	3
0.0756944	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID	SAM_AAA	Launcher	2
0.0763889	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID	SAM_AAA	Launcher	3
0.0777778	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID	SAM_AAA	Launcher	1
0.08125	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID	SAM_AAA	Launcher	4
0.0819444	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID	SAM_AAA	Launcher	1
0.0701389	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID2	SAM_AAA	Launcher	3
0.0708333	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID2	SAM_AAA	Launcher	5
0.0715278	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID2	SAM_AAA	Launcher	3
0.0736111	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID2	SAM_AAA	Launcher	2
0.0743056	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID2	SAM_AAA	Launcher	5
0.075	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID2	SAM_AAA	Launcher	1
0.0756944	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID2	SAM_AAA	Launcher	3
0.0763889	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID2	SAM_AAA	Launcher	4
0.0805556	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID2	SAM_AAA	Launcher	3
0.0701389	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID3	SAM_AAA	Launcher	2
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0.0715278	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID3	SAM_AAA	Launcher	4
0.0722222	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID3	SAM_AAA	Launcher	6
0.0729167	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID3	SAM_AAA	Launcher	4
0.0736111	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID3	SAM_AAA	Launcher	4
0.0743056	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID3	SAM_AAA	Launcher	2
0.075	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID3	SAM_AAA	Launcher	1
0.0770833	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID3	SAM_AAA	Launcher	3
0.0701389	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID4	SAM_AAA	Launcher	3
0.0708333	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID4	SAM_AAA	Launcher	3
0.0715278	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID4	SAM_AAA	Launcher	5
0.0722222	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID4	SAM_AAA	Launcher	3
0.0729167	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID4	SAM_AAA	Launcher	4
0.0736111	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID4	SAM_AAA	Launcher	3
0.0743056	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID4	SAM_AAA	Launcher	5
0.075	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID4	SAM_AAA	Launcher	4
0.0756944	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID4	SAM_AAA	Launcher	3
0.0763889	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID4	SAM_AAA	Launcher	3
0.0777778	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID4	SAM_AAA	Launcher	3
0.0784722	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID4	SAM_AAA	Launcher	1
0.0701389	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID5	SAM_AAA	Launcher	1
0.0708333	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID5	SAM_AAA	Launcher	1
0.0715278	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID5	SAM_AAA	Launcher	3
0.0722222	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID5	SAM_AAA	Launcher	3
0.0729167	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID5	SAM_AAA	Launcher	3
0.0736111	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID5	SAM_AAA	Launcher	3
0.0743056	Controller	Controller	DPICM-MLR	180	31.9375	41.2486	ZSU-38ID5	SAM_AAA	Launcher	4

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